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SMALL MAMMALS OF SANTA ROSA, SOUTHWESTERN IMBABURA PROVINCE, ECUADOR

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ABSTRACT

In 2008 a mammal survey was conducted in humid tropical forest on the western slope of the Andes near the town of Santa Rosa. Sherman traps, tomahawk traps, pitfall traps, and mist nets were used to collect mammal specimens at two sites (450 m elevation and 702 m elevation). A total of 113 specimens of 32 species were collected from the survey area. Seventeen Chiropteran species (*Saccopteryx bilineata*, *Anoura fistulata*, *Glossophaga soricina*, *Micronycteris megalotis*, *Phyllostomus discolor*, *Carollia perspicillata*, *Sturnira bogotensis*, *Sturnira luisi*, *Artibeus jamaicensis*, *Dermanura rava*, *Dermanura rosenbergii*, *Platyrrhinus vittatus*, *Vampyriscus nymphaea*, *Vampyressa thyone*, *Eumops auripendulus*, *Eptesicus innoxius*, and *Myotis albescens*) and one rodent species (*Sigmodontomys aphrastus*) represent new records for southwestern Imbabura. New elevation records also were documented for *Anoura fistulata* and *Sturnira bogotensis*. Shannon diversity analyses of the Chiropteran fauna and overall mammal diversity indicated greater diversity at the 450 m site.

Key words: Ecuador, mammal range records, Santa Rosa, southwestern Imbabura

RESUMEN

En el 2008 se llevó a cabo una evaluación de mamíferos en un bosque húmedo tropical de las estribaciones occidentales de los Andes cerca del pueblo de Santa Rosa. Se utilizaron trampas tipo Sherman, Tomahawk, de caída y redes de neblina para coleccionar mamíferos de dos localidades (a 450 y 702 m de altitud). Un total de 113 especímenes de 32 especies fueron colectados en el área de estudio. Diecisiete especies de quirópteros (*Saccopteryx bilineata*, *Anoura fistulata*, *Glossophaga soricina*, *Micronycteris megalotis*, *Phyllostomus discolor*, *Carollia perspicillata*, *Sturnira bogotensis*, *Sturnira luisi*, *Artibeus jamaicensis*, *Dermanura rava*, *Dermanura rosenbergii*, *Platyrrhinus vittatus*, *Vampyriscus nymphaea*, *Vampyressa thyone*, *Eumops auripendulus*, *Eptesicus innoxius*, y *Myotis albescens*) y una especie de roedor (*Sigmodontomys aphrastus*) representan registros nuevos para el suroccidente de Imbabura. Se documentaron nuevos

registros altitudinales para *Anoura fistulata* y *Sturnira bogotensis*. Análisis de diversidad de Shannon para la fauna de quirópteros y en general la mastofauna indicaron una mayor riqueza para la localidad a 450 m.

Palabras clave: Ecuador, rango de vida de mamíferos, Santa Rosa, suroeste de Imbabura

INTRODUCTION

Ecuador has been the subject of mammal surveys since at least the early 1900s (e.g., Allen 1903; Anthony 1924; Tate 1931). More recently, L. Albuja and D. Tirira (Albuja 1999; Tirira 2007, 2008) have conducted mammal survey work in Ecuador. However, some regions of Ecuador, such as southwestern Imbabura Province, have received little attention and the mammal fauna of those areas remains largely undocumented.

This study was conducted from 21 July to 11 August 2008 at two sites (450 m and 702 m elevation) in western humid tropical forest (Tirira 2007, 2008) near the town of Santa Rosa, Imbabura Province, on the western slope of the Andes. Western Ecuador is characterized by high mammalian diversity, particularly in the northern portion of the country in the provinces of Esmeraldas and Pichincha (Tirira 2007, 2008). Therefore, it was expected that the local mammalian diversity of Imbabura would be represented by more

species than those currently reported (Tirira 2007, 2008). The study sites were therefore chosen because of the low number of documented mammals in southwestern Imbabura and to investigate differences in mammalian diversity due to changes in elevation in a small area (Tirira 2007, 2008).

This survey is important because there are many recent threats to the biodiversity of this area, such as copper mining (Lee et al. 2006b, 2006c, 2008; Finer et al. 2009; Bratton pers. com.). Further, it is difficult to secure collections in Ecuador, and there remain many questions regarding the taxonomy of Ecuador's mammalian fauna (Anthony 1924). The long-term goal of this project and related studies is to acquire comparative material to facilitate studies of biogeography, ecology, and evolution of mammals in Ecuador (Jarrín and Fonseca 2001; Lee et al. 2006b, 2006c, 2008).

STUDY AREA AND METHODS

Two locations were surveyed during this study (Fig. 1). Both sites are within the drainage of the Río Guayllabamba. Site 1 is located 10 km east of Santa Rosa at 702 m elevation (0°19'51"N, 78°55'55"W). This area is on the lower western slope of Cotacachi. The habitat is a mix of mostly secondary forests with some primary riparian and primary upland forests. The patches of primary forest have many tall, buttressed trees that are covered in epiphytes, most of which are members of the plant family Bromeliaceae. There are cleared areas that contained Araceae and Arecaceae (*Iriarte* sp.).

The second location (Fig. 1) is located 1 km east of Santa Rosa at 450 m elevation (0°17'33"N, 78°57'38"W). This area consists of secondary forests, orchards, and a road. Most of the traps and nets were

set near or on a large stream (15 m across). This site has many Moraceae, Araceae, Cyclanthaceae, Costaceae, and Arecaceae (*Iriarte* sp.), and some Rubiaceae and Musaceae along the stream banks. Identification of the plant families was conducted using Patzelt (2004), and photos of plants from the study area were examined by Ken Sytsma (Department of Botany, University of Wisconsin).

Sherman and tomahawk traps were set along hiking trails on the forest floor, in trees, in streams, on logs that traversed streams, and on stream banks for 1,450 trap nights. Pitfall traps were set in forests and along stream banks and logs. Bats were caught with mist nets (5 per site, per night) over natural streams and over hiking trails. Each site was sampled for 7 nights. Captured animals were treated in accordance with the

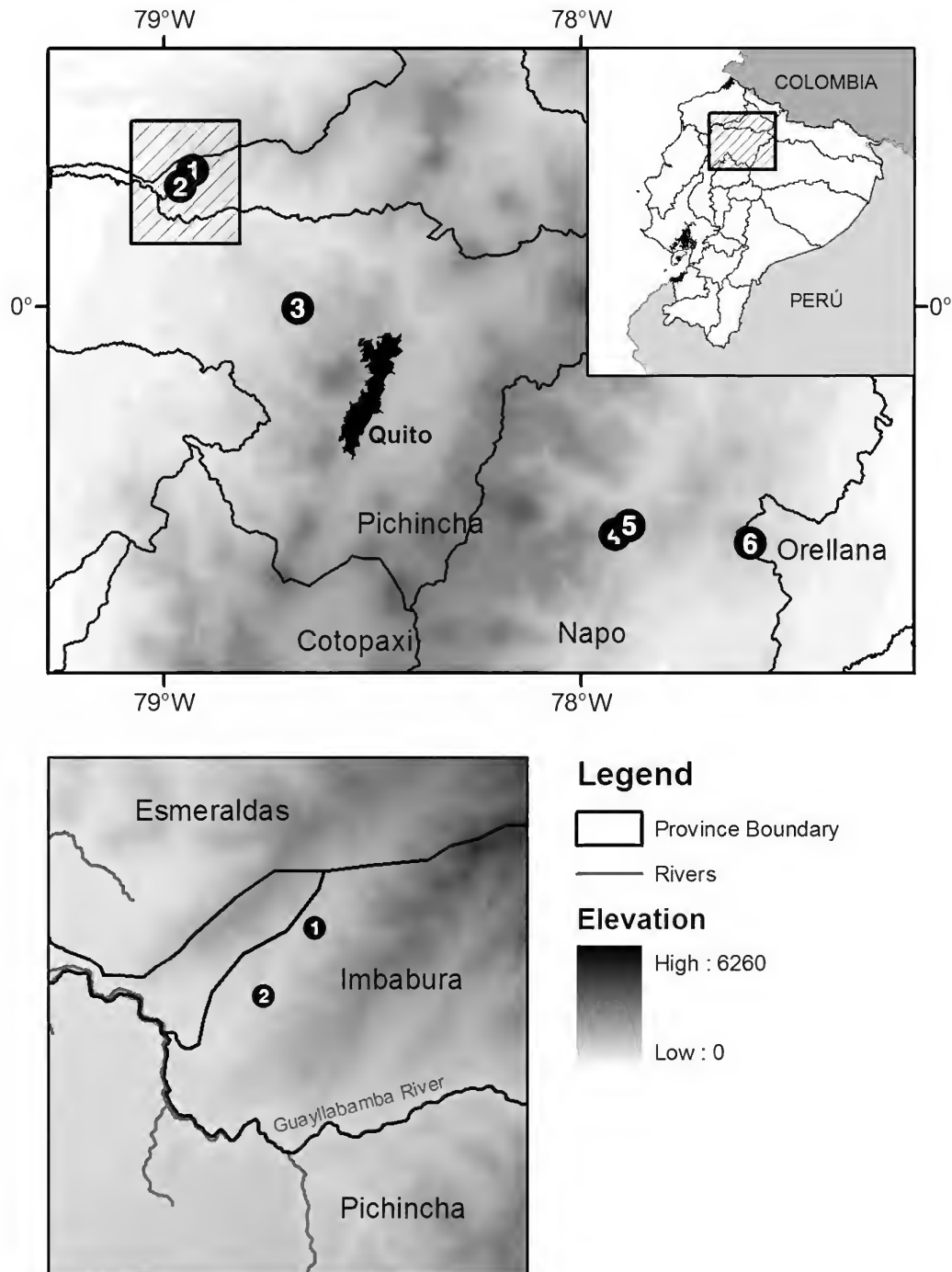


Figure 1. The location of the study sites in southwestern Imbabura Province, Ecuador. Site 1 (also see inset map) is the 702 m site ($0^{\circ}19'51''\text{N}$, $78^{\circ}55'55''\text{W}$) and Site 2 is the 450 m site ($0^{\circ}17'33''\text{N}$, $78^{\circ}57'38''\text{W}$). Sites of previously published studies used for comparison are as follows: the Tandayapa Valley, Site 3 ($0^{\circ}00'13''\text{N}$, $78^{\circ}40'70''\text{W}$); the Cosanga River Valley, Sites 4 ($0^{\circ}33'00''\text{S}$, $77^{\circ}55'00''\text{W}$) and 5 ($0^{\circ}31'70''\text{S}$, $77^{\circ}52'99''\text{W}$); and the eastern slope of Volcán Sumaco, Site 6 ($0^{\circ}34'19''\text{S}$, $77^{\circ}35'64''\text{W}$).

guidelines of the American Society of Mammalogists for the use of wild mammals in research (Gannon and Sikes 2007). All voucher specimens (skins, skulls, skeletons, and frozen liver tissue) were deposited in the Abilene Christian University Natural History Collection (ACUNHC) and Sección de Mastozoología - Museo de Zoología Pontificia Universidad Católica del Ecuador (QCAZ). Specimens from this study were compared with specimens in the collections of Abilene Christian University Natural History Collection, United States National Museum, the British Museum of Natural History, and Sección de Mastozoología - Museo de Zoología, Pontificia Universidad Católica del Ecuador

to confirm species identity. Some specimens were examined by other researchers of Neotropical mammals to further corroborate species identifications. Nomenclature follows Wilson and Reeder (2005) and Gardner (2007) except for *Dermanura*, which follows Hofer et al. (2008), and the Oryzomyine rodents, which follows Weksler et al. (2006).

A Shannon Index (Shannon 1948) was calculated for Chiropteran and overall mammalian diversity at each of the two study sites. These values were compared to diversity values in the published literature for other sites in Ecuador.

RESULTS

In total, 113 specimens of 32 species of small mammals were collected. Twenty-three species were collected at the 450 m site and 15 species were collected at the 702 m site (Table 1). Six species, *Philander opossum*, *Melanomys caliginosus*, *M. megalotis*, *Carollia brevicauda*, *C. castanea*, and *Platyrrhinus vittatus*, were found in both locations. Eighteen of the taxa collected represent new records for southwestern Imbabura Province. Two samples represent extensions in elevation ranges (*Anoura fistulata* and *Sturnira bogotensis*) (Tirira 2007, 2008).

ORDER DIDELPHIMORPHIA

Family Didelphidae

Didelphis marsupialis Linnaeus 1758

Common Opossum

One specimen (QCAZ 10980) was collected in a tomahawk trap set along the banks of a stream at the 450 m site (Tirira 2007, 2008). This specimen has the light tan color-pattern characterizing *D. marsupialis etensis* specimens housed at the U.S. National Museum (USNM 121135-121138). For basic measurements see Table 1.

Philander opossum (Linnaeus 1758)

Gray Four-eyed Opossum

Three specimens, one male (ACUNHC 1409) and two females (QCAZ 10477, 10478), were collected.

The male was collected at 450 m; the two females were collected at 702 m and both were carrying juveniles. Although color varied in these specimens, none exhibited characters of *P. andersoni* (Castro-A. et al. 2000; Tirira 2008). These specimens were collected well within the recorded range and elevation for the species (Tirira 2008). For basic measurements see Table 1.

ORDER CHIROPTERA

Family Emballonuridae

Saccopteryx bilineata (Temminck 1838)

Greater Sac-winged Bat

One male (QCAZ 10481) was collected at 450 m. This species was not documented previously from southwestern Imbabura (Tirira 2007), but has been reported from northern Esmeraldas and southern Santo Domingo de los Tsáchilas (Tirira 2008). This specimen represents a major range record, as the nearest previous record was 70 km north of our study area (Tirira 2008). The head and body of this specimen measured 58 mm; this measurement, and the twin stripes on the blackish back, separate this species from other Emballonurids (Yancey et al. 1998). For basic measurements see Table 1.

Table 1. Presented are range status, collecting site, and measurements (mm) of mammal specimens collected near Santa Rosa, Ecuador. Range designations are as follows: R = major range records (species not expected in Imbabura and not previously documented within 70 km of the study sites); P = new, but expected records for Imbabura Province, (species previously documented in bordering provinces); E = elevation records; Known = species was previously documented from southwestern Imbabura. Site 1 is the 702 m site; Site 2 is the 450 m site.

Species	Range	Site	Total length	Tail length	Hind foot	Ear	Forearm length
<i>Didelphis marsupialis</i>	Known	2	871	470	64	41	N/A
<i>Philander opossum</i>	Known	1 and 2	510-573	257-276	44-46	33-36	N/A
<i>Saccopteryx bilineata</i>	R	2	74	16	13	16	47
<i>Anoura fistulata</i>	P, E	1	75	10	11	13	41
<i>Glossophaga soricina</i>	P	1	90	11	16	15	44.5
<i>Micronycteris megalotis</i>	P	1 and 2	64-65	16	11-12	17-20	35-35.5
<i>Phyllostomus discolor</i>	P	2	99-110	15-16	13-19	19-21	64.5
<i>Carollia brevicauda</i>	Known	1 and 2	65-95	9-19	11-21	14-20	36-43
<i>Carollia castanea</i>	Known	1 and 2	63-73	11-21	12-17	13-20	35-38
<i>Carollia perspicillata</i>	P	2	78-85	11-14	14-16	17-22	42.8-44.5
<i>Rhinophylla alethina</i>	Known	2	54-65	0	7-14	9-14	31.4-37
<i>Sturnira bogotensis</i>	P, E	1	68	0	12	17	45
<i>Sturnira luisi</i>	P	1	67-73	0	13-19	17-20	42-45
<i>Sturnira ludovici</i>	Known	1	72-76	0	13-15	14-20	44-48
<i>Artibeus jamaicensis</i>	P	2	95	0	21	21	63
<i>Dermanura rava</i>	P	2	57-59	0	11-13	13-15	38-40
<i>Dermanura rosenbergii</i>	P	2	56-64	0	9-12	14-16	37-39.3
<i>Platyrrhinus vittatus</i>	R	1 and 2	86-105	0	16-21	19-23	56-58
<i>Platyrrhinus dorsalis</i>	Known	2	75-87	0	11-18	16-19	48-52.5
<i>Vampyriscus nymphaea</i>	P	2	63-66	0	12	16-18	37.4-38
<i>Vampyressa thyone</i>	P	2	56	0	11	13	31
<i>Eumops auripendulus</i>	R	2	138-153	50-58	12-16	19-24	59-62
<i>Eptesicus innoxius</i>	R	1	90	35	9	13	40
<i>Myotis albescens</i>	P	2	89-93	31-40	9-12	12-16	35-37
<i>Heteromys australis</i>	Known	2	253-265	138-144	35	15-16	N/A
<i>Melanomys caliginosus</i>	Known	1 and 2	188-225	81-102	27-30	14-16.5	N/A
<i>Sigmodontomys aphrastus</i>	R	1	346	207	36	16	N/A
<i>Transandinomys bolivaris</i>	Known	2	203	102	29	18	N/A

Table 1. (cont.)

Species	Range	Site	Total length	Tail length	Hind foot	Ear	Forearm length
<i>Handleyomys alfaroi</i>	Known	2	207	105	28	17	N/A
<i>Dasyprocta punctata</i>	Known	2	520	18	130	39	N/A
<i>Cuniculus paca</i>	Known	1	Skull only				
<i>Haplomys gymnurus</i>	Known	1	467	202	62	26	N/A

Family Phyllostomidae

Anoura fistulata

Muchhala, Mena-V., and Albuja-V. 2005

Tube-lipped Long-tongued Bat

One female (QCAZ 10492) was collected at 702 m. This animal was found below the recorded lower limit of the elevation range for the species (1060 m) and is the first *Anoura* reported from southwestern Imbabura (Tirira 2008). This specimen had a very long tongue (70 mm) and there was a split in the lower lip, both of which are important characteristics of the species (Muchhala and Albuja 2005; Mantilla-M. and Baker 2006). For basic measurements see Table 1.

Glossophaga soricina (Pallas 1766)

Pallas's Long-tongued Bat

A single male (QCAZ 10529) was collected at 702 m in a net within a gallery forest. There are no previous records for this species in humid forests of southwestern Imbabura Province (Tirira 2008). This specimen had four lower incisors of equal size, which is a diagnostic character for distinguishing this species from other glossophaginae bats (Albuja 1999). For basic measurements see Table 1.

Miconycteris megalotis (Gray 1842)

Little Big-eared Bat

One male (QCAZ 10533) was collected at 702 m and one female (ACUNHC 1411) was collected at 450 m. Although these specimens were collected within their known elevation ranges, these are new

records for southwestern Imbabura Province (Tirira 2008). These specimens have a smooth chin pad and four lower incisors. The pelage is 8 to 10 mm long and the body length is less than 55 mm (Simmons and Voss 1998). These characters separate this species from other Phyllostominae bats. For basic measurements see Table 1.

Phyllostomus discolor Wagner 1843

Pale Spear-nosed Bat

Two females (ACUNHC 1410, QCAZ 10535) were collected from a banana orchard near 450 m elevation. One specimen contained an embryo (16 mm). There are no previous records for this species from southwestern Imbabura Province (Tirira 2008). These specimens had a forearm less than 65 mm and the dorsal fur was brown with the tips of the hair white, which matches the description for this species (Santos et al. 2003). For basic measurements see Table 1.

Carollia brevicauda (Schinz 1821)

Silky Short-tailed Bat

Three males (QCAZ 10499, 10503, 10509) and two females (QCAZ 10501, 10507) were caught at 450 m. Five males (ACUNHC 1447, 1450, 1451, 1454, QCAZ 10511) were caught at 702 m. These specimens were found well within their known geographic and elevation ranges (Tirira 2008). The outer incisors were not obscured by cingula of canines, an identifying characteristic for this species (Pine 1972). For basic measurements see Table 1.

Carollia castanea (H. Allen 1890)
Chestnut Short-tailed Fruit Bat

A total of 14 specimens were collected at the two locations. Seven were taken at 702 m (five males and two females, QCAZ 10500, 10502, 10504, 10506, 10508, 10510, 10512) and seven (three males and four females, ACUNHC 1441-1446, 1452) were collected at 450 m. Two of the females at the 450 m site had one embryo each. These specimens were found well within the known geographic and elevation ranges for the species (Tirira 2008). The distinguishing character used to discern this species was that the second lower premolar was about twice as high as the first (Pine 1972). For basic measurements see Table 1.

Carollia perspicillata (Linnaeus 1758)
Seba's Short-tailed Bat

Four *C. perspicillata* (one male and three females, ACUNHC 1448, 1453, QCAZ 10520, 10521) were collected at 450 m. There are no previous records of this species for southwestern Imbabura. The nearest records are from Pichincha (23 km south) (Tirira 2008). The outer incisors were obscured by cingula of canines on these specimens (Pine 1972), which is a distinguishing characteristic for the species. For basic measurements see Table 1.

Rhinophylla alethina Handley 1966
Hairy Little Fruit Bat

Five males and seven females (ACUNHC 1435-1440, QCAZ 10552-10554, 10556, 10557, 10563) were collected at 450 m. Two females contained embryos. These specimens were found within the geographic range of the species (Tirira 2008). These specimens did not have distinctly notched upper incisors; this character is used to distinguish this species from other congeners (Rinehart and Kunz 2006). For basic measurements see Table 1.

Sturnira bogotensis Shamel 1927
Bogota Yellow-shouldered Bat

A single female (QCAZ 10568) was collected at 702 m. This specimen represents a new elevation

record because it was found 660 m lower than the previous record (Tirira 2007). There are no previous records for this species in southwestern Imbabura (Tirira 2008). For basic measurements see Table 1.

Sturnira luisi Davis 1980
Luis's Yellow-shouldered Bat

Seven *S. luisi* were collected at 702 m (two males and five females, ACUNHC 1424-1426, QCAZ 10505, 10566, 10569, 10573). There are no previous records for this species in southwestern Imbabura. The most proximate record is just south (23 km) of the province border in Pichincha Province (Tirira 2008). Identification of these bats was based on the straight maxillary arm of the zygomatic arch, which forms a continuous line with the rostrum (Giannini and Barquez 2003). For basic measurements see Table 1.

Sturnira ludovici Anthony 1924
Highland Yellow-shouldered Bat

Four individuals of *S. ludovici* (two males and two females, ACUNHC 1422, 1423, QCAZ 10564, 10574) were collected at 702 m. This species was collected within its known geographic range (Tirira 2007, 2008). The specimens were identified to species by size, shape of its palate, and location on the western slope of the Andes (Giannini and Barquez 2003). For basic measurements see Table 1.

Artibeus jamaicensis Leach 1821
Jamaican Fruit-eating Bat

One female specimen with one embryo (QCAZ 10497) was collected at 450 m. This is well within the geographic range of the species. There are no previous records for this species in southwestern Imbabura, but the species is known from the provinces to the north (Esmeraldas) and south (Pichincha) of Imbabura (Tirira 2008). For basic measurements see Table 1.

Dermanura rava Miller 1902
Pygmy Fruit-eating Bat

Three specimens, two males and a female, were collected at 450 m (ACUNHC 1419, QCAZ 10576,

10577). There are no previous records for this species in southwestern Imbabura. However, this species is known from the provinces to the north (Esmeraldas) and south (Pichincha) of Imbabura (Tirira 2008). These specimens have two upper and two lower molars and the dorsal pelage is a grayish brown, similar to the published descriptions for *D. rava* (Handley 1987). For basic measurements see Table 1.

***Dermanura rosenbergii* Thomas 1897**
Rosenberg's Fruit-eating Bat

Three specimens, two males and one female, were collected at 450 m (ACUNHC 1420, QCAZ 10494, 10495). Like *D. rava*, there are no previous records for this species in southwestern Imbabura, but the species is found in the provinces to the north (Esmeraldas) and south (Pichincha) (Tirira 2008). The specimens were identified to species based on their maxillary tooth row length of 6.3 mm (Handley 1987). For basic measurements see Table 1.

***Platyrrhinus vittatus* (Peters 1859)**
Greater Broad-nosed Bat

One male and one female (QCAZ 10537, 10538) were collected at 702 m. Two males and four females (ACUNHC 1412, 1414, 1416, 1417, QCAZ 10539, 10543) were collected at 450 m. These specimens represent the first records of *P. vittatus* in Ecuador (Tirira 2007, 2008). When tissue samples from these specimens were sequenced for the ND-2 mtDNA gene and compared with other congeners, the specimens clustered with specimens that are attributed to *P. vittatus* (Velazco pers. com.). Further, the greatest length of the skulls for these specimens was 31.43-32.56 mm, which conforms to descriptions by Velazco (2005) for *P. vittatus*. However, our specimens do not completely conform to the morphological characters that are used to distinguish *P. vittatus* from *P. alberticoi* – our specimens are missing the accessory cusp on the second lower premolar, a characteristic that is usually diagnostic of *P. alberticoi* (Velazco 2005). For basic measurements see Table 1.

***Platyrrhinus dorsalis* (Thomas 1900)**
Thomas's Broad-nosed Bat

Five males and two females (ACUNHC 1413, 1415, 1418, QCAZ 10542, 10544-10546) were collected at 450 m. This species has been recorded previously in southwestern Imbabura (Tirira 2008). These specimens conform to the descriptions for *P. dorsalis* presented by Velazco (2005). Further, three specimens were sequenced for ND-2 and they formed a monophyletic clade with other *P. dorsalis* samples (Velazco pers. com.). The greatest length of skull (GSL) measurements for these specimens was 27.65-28.80 mm, which is slightly larger than the descriptions by Velazco (2005). For basic measurements see Table 1.

***Vampyriscus nymphaea* Thomas 1909**
Striped Yellow-eared Bat

Two females (ACUNHC 1421, QCAZ 10532) were collected at 450 m. These specimens were taken on the eastern edge of their range (Tirira 2007) and represent new records for southwestern Imbabura (Tirira 2008). Bats of the genus *Vampyriscus* can be characterized by their dentition (Lewis and Wilson 1987). These specimens had two pairs of lower incisors, no third molar, and low anterior and posterior cusps on the second molar. For basic measurements see Table 1.

***Vampyressa thuyone* Thomas 1909**
Northern Little Yellow-eared Bat

One female (QCAZ 10531) was collected at 450 m. This specimen contained one embryo. There are no previous records for this species from southwestern Imbabura, but the species has been collected near Imbabura in both Pichincha and Esmeraldas Provinces (Tirira 2008). This specimen had two pairs of lower incisors, no third molar, and high anterior and posterior cusps on the second molar (Lewis and Wilson 1987). For basic measurements see Table 1.

Family Molossidae

Eumops auripendulus (Shaw 1800)

Black Bonneted Bat

Six female specimens (ACUNHC 1406-1408, QCAZ 10485-10487) were collected from a house near 450 m. Three of these specimens contained embryos 45-78 mm in length. These specimens represent the most northern record for Ecuador and the first record for Imbabura (Tirira 2007). This sample is very disjunct from any other populations found in Ecuador, with the nearest records 160 km southwest of Santa Rosa (Tirira 2007). For confirmation of the morphological identification, specimens were subjected to DNA sequencing of the cytochrome *b* gene (Ammerman pers. com.). For basic measurements see Table 1.

Family Vespertilionidae

Eptesicus innoxius (P. Gervais 1841)

Harmless Serotine

One male (QCAZ 10579) was collected in a dwelling at 702 m. The next most proximate range record is from central Los Ríos Province (195 km south of this site) (Tirira 2008). This specimen has a sagittal crest and the skull is 14.2 mm in length; these characters are diagnostic of *E. innoxius* (Tirira 2007; 2008). For basic measurements see Table 1.

Myotis albescens (E. Geoffroy 1806)

Silver-tipped Myotis

Five males and two females (ACUNHC 1427-1429, QCAZ 10580-10583) were collected (from the same house as *E. auripendulus*) near 450 m. One individual had a single embryo. There are no previous records of *M. albescens* in southwestern Imbabura (Tirira 2007, 2008). These specimens are distinguished from other *Myotis* by their white-tipped dorsal hair or frosted look (Albuja 1999). For basic measurements see Table 1.

ORDER RODENTIA

Family Heteromyidae

Heteromys australis Thomas 1901

Southern Spiny Pocket Mouse

Three specimens, two males and one female (ACUNHC 1489, QCAZ 10482, 10484), were collected at 450 m from logs that traversed a small stream less than 2 m across. This species was collected near the southeastern edge of its range in Ecuador (Tirira 2007, 2008). This species and *H. teleus* are known from less than 70 specimens in total from Ecuador (Anderson and Jarrín-V. 2002). In the field we measured the hind foot at 35 mm for all the specimens, which initially would suggest that the specimens were *H. teleus*. However, Anderson and Jarrín (2002) measured (with digital calipers) dry museum specimens in their analysis of *Heteromys*; dry hind foot length in our specimens is 33 mm, which indicates *H. australis*. Robert Anderson confirmed our identification (Anderson pers. com.). For basic measurements see Table 1.

Family Cricetidae

Melanomys caliginosus (Tomes 1860)

Dusky Melanomys

Four specimens, two males and two females (ACUNHC 1405, QCAZ 10419, 10420, 10422), were collected at 450 m. One male (ACUNHC 1404) was collected at 702 m. These specimens were collected within the known range of the species (Tirira 2007, 2008). Cytochrome *b* analyses confirmed the identification of these specimens (Hanson and Bradley 2008). For basic measurements see Table 1.

Sigmodontomys aphrastus (Harris 1932)

Long-tailed Sigmodontomys

One male (QCAZ 10427) was collected at 702 m. This specimen represents only the third (and most northern) record for this species in Ecuador and the

first for Imbabura (Tirira 2007, 2008). It was collected in a mixed forest and tall-grass area within 10 m of a stream. The other published specimens were found in the same ecotonal region in Pichincha (Tirira 2008). The identification of this specimen was confirmed by sequencing the cytochrome *b* gene (Hanson pers. com.). For basic measurements see Table 1.

***Transandinomys bolivaris* J. A. Allen 1901**
Long-whiskered Trans-Andean Rat

One female (QCAZ 10474) was collected at 450 m. This specimen was found within its recorded range and elevation (Tirira 2007, 2008). The morphological identification was confirmed by sequencing cytochrome *b* (Hanson pers. com.). For basic measurements see Table 1.

***Handleyomys alfaroi* (J. A. Allen 1891)**
Alfaro's Rice Rat

One male (QCAZ 10428) was collected at 450 m. This specimen was found within its recorded range and elevation (Tirira 2007, 2008). The morphological identification was confirmed by sequencing cytochrome *b* (Hanson pers. com.). For basic measurements see Table 1.

Family Dasyproctidae
***Dasyprocta punctata* Gray 1842**
Central American Agouti

One male was obtained from a hunter near 450 m. The dorsal pelage was agouti brown. The only other *Dasyprocta* species in Ecuador is *D. fuliginosa*, which is black on the dorsum (Lee et al. 2006a), unlike this specimen. This specimen was taken within its known geographic range (Tirira 2008). For basic measurements see Table 1.

Family Cuniculidae
***Cuniculus paca* (Linnaeus 1766)**
Lowland Paca

One skull (QCAZ 10475) was salvaged from a dwelling located at 702 m. This specimen was found within its geographic range (Tirira 2007, 2008).

Family Echimyidae
***Hopломys gymnurus* (Thomas 1897)**
Armored Rat

One female (QCAZ 10480) was collected at 702 m. This specimen was collected at the southeastern edge of its range in Ecuador (Tirira 2007, 2008). For basic measurements see Table 1.

DISCUSSION

The Chiropteran species richness, diversity, and elevation records documented in this study for the two sites in southwestern Imbabura Province can be compared to each other and to previously published reports from the eastern Andes (Cosanga, Otonga, and Volcán Sumaco) and the western Andes (Guajalito and Tandayapa) (Jarrín and Fonseca 2001; Lee et al. 2006b, 2006c, 2008) (Table 2). In the current study, 22 Chiropteran species were documented for the two sites combined; 16 species were captured at the 450 m site and 10 species were captured at the 702 m site. In comparison, bat species documented in other studies were as follows: Otonga, 18; Tandayapa, 13; Guajalito, 16; Cosanga, 15; and Volcán Sumaco, 8 (Table 2). When comparing these study areas, the greatest spe-

cies richness was found at the lowest elevations (22 species, this study) and the lowest richness was found at the highest elevation (8 species, Volcán Sumaco). Similarly, Shannon diversity indices (Shannon 1948) for this study were highest for the 450 m site ($H^p = 1.10$) and for the two sites combined ($H^p = 1.19$); species diversity at the 702 m site ($H^p = 0.86$) was lower because of the dominance of *C. castanea* ($n = 7$) and *S. luisi* ($n = 7$) in the samples. When comparing all the studies, bat diversity was lowest at the highest elevation (Volcán Sumaco).

Total mammalian species richness and diversity also can be compared between this study and three previous studies in Ecuador (Lee et al. 2006b, 2006c,

Table 2. Comparison of Chiropteran and overall mammalian species richness and diversity (H^p) between this study and previously published studies in Ecuador.

Location	Elevation	Bat species recorded	H^p for bats	Total mammal species recorded	H^p for mammals
Imbabura (this study)	450 m	16	1.10	23	1.23
Imbabura (this study)	702 m	10	0.86	15	1.03
Imbabura (this study)	450-702 m	22	1.19	32	1.31
Otonga (Jarrín and Fonseca 2001)	1300-2300 m	18	1.02	N/A	N/A
Tandayapa (Lee et al. 2006b)	1500-2100 m	13	0.88	19	0.99
Guajalito (Jarrín and Fonseca 2001)	1800-2000 m	16	1.03	N/A	N/A
Cosanga (Lee et al. 2006c)	1900-2100 m	15	0.82	20	0.91
Volcán Sumaco (Lee et al. 2008)	2500 m	8	0.58	12	0.84

2008) (Table 2). Total mammal species richness and diversity values were as follows: this study, 32 species ($H^p = 1.31$) at both sites, 23 species ($H^p = 1.23$) at the 450 m site, and 15 species ($H^p = 1.03$) at the 702 m site; Cosanga, 20 species ($H^p = 0.91$); Tandayapa, 19 species ($H^p = 0.99$); and Volcán Sumaco, 12 species ($H^p = 0.84$).

Overall, the comparison of the various Ecuador studies suggests a general trend of greater species richness and diversity at lower elevations and lower species richness and diversity at higher elevations. These results are similar to studies in Peru showing decreasing chiropteran diversity with increasing elevation (Patterson et al. 1996). In the Ecuadorian studies compared here, there appears to be less correlation at intermediate elevations. However, this likely is due

to the wide range of elevations within the Otonga and Tandayapa study areas and the overlap in elevation ranges between several of the studies.

Many of the species collected during this study were expected, yet 18 of 32 were documented for the first time in southwestern Imbabura. It is beneficial to conservation organizations to have documentation of species composition in an area such as Santa Rosa so these organizations do not need to devote their limited budgets to the task of surveying. The long-term conservation status of Santa Rosa is uncertain. The people of the region are concerned about their forests and therefore practice sustainable forestry; they use zip lines to carry crude boards down mountain slopes and thus have no need to build extensive logging roads, and many people in Santa Rosa expressed interest in

maintaining high bird diversity for ecotourism. However, there are copper deposits in the area and mining companies are advocating mining this location (Bratton

pers. com.), which poses a potential threat to species diversity and conservation efforts.

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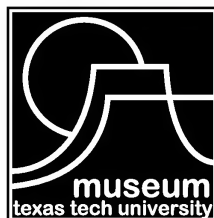
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